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THE

JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME VI, No. 6

STOMATOPOD LARVÆ

BY

G. E. H. FOXON, M.A., F.L.S.

(University College, Cardiff)

WITH FOUR TEXT-FIGURES

LONDON:
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B. Quaritch, Ltd., 11 Grafton Street, New Bond Street, London, W.1; Dulau & Co., Ltd., 29 Dover Street, London, W.1; Oxford University Press, Warwick Square, London, E.C.4; H.M. Stationery Office, London, S.W.1
AND AT
The British Museum (Natural History), Cromwell Road, London, S.W.7
1939

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Price Two Shillings

[Issued 28th October, 1939]

DESIGNED AND
PRINTED
BY
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WITH FOUR TEXT-FIGURES.

INTRODUCTION.

This collection of Stomatopod larvæ is interesting in that it contains examples of several "classical" types such as formed the basis of Claus's "Die Metamorphose der Squilliden". Unfortunately, however, it does not permit of any further larvæ being referred to specific adults, although some suggestions are put forward concerning certain of the *Alima* larvæ of *Squilla*. Turning to the other genera, in *Pseuderichthus* some peculiarities of *P. communis* have been pointed out; in *Lysioerichthus* attention has been drawn to Tattersall's questions concerning *L. duvaucellii*, and an attempt has been made to draw together under the name *L. rostratus* a number of very similar larvæ which appear to belong here and may be the larvæ of *Lysiosquilla multifasciata*. The specimens in the collection enable certain of the developmental stages of *Lysioerichthus rostratus* and *Coronideriehthus bituberculatus* to be followed. The genera *Gonodactylus* and *Odontodactylus* are not represented in their larval stages.

The greater part of the examination of the collection was carried out in 1937 in the Zoology Department of the University of Glasgow. It was decided that it would be better if the completion of the report was delayed until that on the adult Stomatopoda by Dr. Chopra was available, as it would enable references to that report to be made. The report on the adults reached me in January, 1939, and, in the interval, I had also received a few further specimens which had been sent to Dr. Chopra, but which were too immature to be considered in his report. This account of the larval forms has been concluded in the Department of Zoology and Comparative Anatomy, University College, Cardiff.

I wish to express my thanks to the following: Lt.-Col. R. B. Seymour Sewell, F.R.S., for the opportunity of examining this collection; the Trustees of the British Museum (Natural History) for allowing me to examine material in the Museum and for the loan of specimens for comparison; Prof. E. Hindle and Prof. W. M. Tattersall for the facilities offered for my work at Glasgow and Cardiff respectively.

* From the Departments of Zoology in the University of Glasgow and the University College of South Wales and Monmouthshire.

LIST OF STATIONS AT WHICH STOMATOPOD LARVÆ WERE OBTAINED.

Red Sea.

7. 16.ix.33. 13° 58′ 48″ N., 42° 22′ 42″ E.
   2 m. Plankton, 100–0 m., oblique.
   2 m. Stramin, 100–0 m. ,,
   Alima spp., *Pseuderichthus communis.*

Gulf of Oman.

71. 26.xi.33. 25° 35′ 00″ N., 56° 42′ 18″ E., to 25° 43′ 00″ N., 56° 39′ 18″ E.
   Otter trawl, 106 m. *Alima* spp.
76. 29.xi.33. 24° 13′ 54″ N., 59° 03′ 30″ E., to 24° 16′ 42″ N., 59° 06′ 06″ E.
   1 m. Stramin, 300 m. *Alima* sp., *Pseuderichthus ?distinguendus.*
   1 m. ,, 1800 m. of wire out. *Alima* sp.
   2 m. Tow-net, 2800 m. ,, ,,

Northern Area of Arabian Sea.

61. 8.xi.33. 61A, 23° 02′ 48″ N., 64° 31′ 54″ E., to 61B, 23° 02′ 30″ N., 64° 41′ 00″ E.
   1 m. Stramin, 500–0 m. *Alima* sp.
   1 m. ,, 1000–0 m. ,,
   1 m. ,, 1500–0 m. ,,
   1 m. Tow-net, 1500–0 m. ,,
   2 m. ,, 2000–0 m. ,,
   8–9.xi.33. 61C, 23° 02′ 12″ N., 64° 33′ 39″ E., to 61D, 23° 02′ 30″ N., 64° 15′ 54″ E.
   5 cm. Net, 0 m. *Alima* sp., *Lysioerichthus rostratus.*
   1 m. Stramin, 1000–0 m. *Alima* sp.
   1 m. Tow-net, 1000–0 m. ,,
   1 m. ,, 1500–0 m. ,,
   2 m. ,, 2000–0 m. ,,
86. 6.xii.33. 19° 20′ 24″ N., 69° 24′ 18″ E., to 19° 25′ 42″ N., 69° 22′ 54″ E.
   Agassiz trawl, 759–1024 m. *Alima* sp., *Lysioerichthus duvaucellii.*

Central Area of Arabian Sea.

96. 19.xii.33. 10° 54′ 42″ N., 61° 20′ 54″ E., to 10° 53′ 18″ N., 61° 22′ 24″ E.
   2 m. Tow-net, 400–645 m. *Lysioerichthus duvaucellii.*
172. 29.iv.33. 9° 40′ 24″ N., 54° 03′ 36″ E., to 9° 42′ 18″ N., 54° 39′ 00″ E.
   1 m. Net, 400–0 m. *Alima* sp., *Lysioerichthus rostratus.*
   1 m. ,, 850–0 m. *Alima* sp., *Lysioerichthus rostratus, Coronideerichthus bituberculatus, Pseuderichthus ?distinguendus.*
   2 m. ,, 2091–0 m. *Alima* sp., *Lysioerichthus duvaucellii, Pseuderichthus ?distinguendus.*

Southern Area of Arabian Sea.

131. 11.ii.34. 1° 39′ 06″ S., 61° 13′ 48″ E., to 2° 07′ 30″ S., 61° 21′ 12″ E.
   1 m. Stramin, 1500 m. of wire out. *Alima* sp.

MALDIVE AREA.

145D. 2.iv.34. 4° 58′ 42″ S., 73° 16′ 24″ E.
1 m. Net, 100–0 m., vertical *Alima* sp.
1 m. ,, 500–0 m. ,, *Lysioerichthus duvaucellii.*

GULF OF ADEN.

186. 5.v.34. 13° 32′ 30″ N., 49° 13′ 06″ E., to 13° 32′ 00″ N., 49° 15′ 18″ E.
1 m. Net, 575–0 m. *Alima* sp.
1 m. ,, 600–0 m. ,, *Coronideriehthus bituberculatus.*
2 m. ,, 950–0 m. ,,

A NOTE ON THE CLASSIFICATION OF STOMATOPOD LARVÆ.

When reporting (1932) on the Stomatopod larvæ of the Great Barrier Reef Expedition, 1928–29, I gave a key to show that the larvæ could be classified in the same way as were the adults by Kemp (1913). Gurney (1937) has since criticized this key, and suggested that the arrangement of the larvæ proposed by Giesbrecht (1910) is more natural. Although some of Gurney's criticisms are valid and do point out weaknesses in my scheme, I am not able to accept the whole of them; in particular his view that the larval development of the genera *Lysiosquilla* and *Coronida* is fundamentally different from that of the other genera must be rejected. From a study of the appendages of the *Lysiosquilla* larvæ collected by the Barrier Reef Expedition, it was concluded that the thoracic appendages 3, 4 and 5 are first used for swimming, and, later, although they do not disappear, undergo transformation into feeding organs. During this transformation they undoubtedly pass through an apparently functionless stage. Should such larvæ hatch later with the appendages in this functionless stage, it would appear obvious that, in the course of evolution, these functionless appendages would undergo complete suppression and would appear later still and in their final form, so giving rise to the type of larva found in the other genera. Thus it was argued that the type of development seen in *Squilla*, *Pseudosquilla*, *Gonodactylus* and *Odontodactylus* is not distinct from that of *Lysiosquilla* and *Coronida* but in all probability is derived from it.

It is obvious that opinions will differ as to the amount and the significance of adaptation to development exhibited by the larvæ, and the present writer believes that a classification based mainly on adult characters and those appearing late in larval life is more likely to lead to a correct appreciation of the interrelationships of the genera than one based mainly on larval development, for the course of larval development is likely to be highly modified by mechanical factors such as the amount of yolk present in the egg and the degree of development on hatching.

It is clear that any attempt to classify the Stomatopoda must take into account both larval and adult characters. It is quite illogical to have one classification for adults and another for larvæ. Kemp's classification of the adults is now universally accepted, and a return to Giesbrecht's scheme, based on the larvæ, would be quite unacceptable to most workers. A point of very great importance made by Kemp is that *Pseudosquilla* is the genus most nearly related to *Squilla*, and no classification can be acceptable which does

not bring out this fact. However, it is not considered that no advance can be made and, below, a "key" to the genera is given which attempts to take account of Gurney's criticisms, and to give expression to them without upsetting the main points of Kemp's classification.

KEY TO THE GENERA OF STOMATOPODA WITH SPECIAL REFERENCE TO LARVAL FORMS.

A. Larvæ hatch with the anterior thoracic appendages biramous and natatory (*Erichthoidina* stage), but which later undergo a transformation to the typical chelate form. The "hand" of the fourth thoracic appendage is rounded, often broader than long, and more than twice as big as that of the fifth thoracic appendage. In the raptorial claw the upper margin of the propodus in the adult is finely pectinate and the ischio-meral articulation terminal.

1. Propodus of raptorial claw broad and dactylus slightly inflated at the base . . . . . *Coronida.* [*Coronideerichthus.*]

2. Propodus of raptorial claw slender and no trace of inflation at the base . . . . . *Lysiosquilla.* [*Lysioerichthus.*]

B. Larvæ hatch with the raptorial claw developed and no appendages on the third, fourth and fifth segments of the thorax; when the appendages of these latter segments appear, the "hand" of the fourth is oblong and generally longer than broad and scarcely bigger than that of the fifth thoracic appendage.

1. In the raptorial claw the ischio-meral articulation is terminal and the upper margin of the propodus in the adult is usually finely pectinate.

(*a*) The first larva hatches with four pairs of pleopods and develops into an *Alima*. Telson with more than four intermediate denticles between submedian and lateral denticles . . . . . *Squilla.* [*Alima.*]

(*b*) The first larva hatches with five pairs of pleopods and develops into an *Erichthus*. Telson with less than four intermediate denticles between the submedian and lateral denticles . . . *Pseudosquilla.* [*Pseuderichthus.*]

2. In the late larva the ischio-meral articulation of the raptorial claw ceases to be terminal, and becomes situated at a point in advance of the proximal end of the merus. The upper margin of the propodus of the raptorial claw is not finely pectinate.

(*a*) The spines of the telson are greatly elongated.
Odontodactylus. [*Odonterichthus.*]

(*b*) The spines of the telson are not greatly elongated.
Gonodactylus. [*Gonerichthus.*]

SYSTEMATIC NOTES.

Squilla, J. C. Fabricius.

The *Alima* larvæ of *Squilla* form a very large part of the collection, but unfortunately no larva can be referred to an adult with any degree of certainty. Our knowledge of this group of larvæ is undoubtedly growing gradually, and it seems possible to obtain now a general idea of the main distinctions between larvæ which belong to different groups of the genus, but which characters indicate specific differences is still a matter which is open to doubt.

To judge from the work of Giesbrecht (1910) and Brooks (1879), the larvæ of the "*mantis*" group would appear to be characterized by a somewhat triangular carapace which is not unduly enlarged. Komai and Tung (1929) have recently described a larva, which they refer to *S. oratoria*, and we may conclude that the larvæ belonging to other species near this will not be very different. Indeed some very similar larvæ are very abundant in the present collection, and are assigned to the "*nepa*" group to which *S. oratoria* is closely allied. In 1932 I tentatively referred a larva from the Great Barrier Reef to *S. lata*, and, more recently, Lebour (1934) has described a somewhat similar larva which she suggests is actually the larva of *S. lata*, the Barrier Reef specimens belonging to the "*lata*" group. This type of larva, which has been referred to the "*lata*" group, is not far removed from the "*Alimerichthus*" type of the older authors. This latter type cannot be referred to a group of adults, but a point which is worth noting is that specimens are known from both the Indo-Pacific region and the South Atlantic, and this must be borne in mind when any attempt at referring them to a specific adult is made. The facts of distribution appear to be very important, and no species of *Squilla*, with the exception of *S. armata*, which is restricted to southern latitudes, is known from both Atlantic and Pacific regions. Nevertheless, Komai and Tung (1929) refer a larva from Japan to *Alima subtruncata* Jurich, which is common in the Atlantic ; but it seems very unlikely that they can be specifically identical. Similarly Lebour (1934) on these same grounds has questioned the identity of certain forms referred to *Alima hyalina* by various authors.

It has frequently been pointed out that the only constant difference between an *Alima* larva and an *Erichthus* is to be found in the spinulation of the telson. The present large collection of *Alima* larvæ has drawn my attention to the very different way in which the telson develops here as compared with the *Erichthus* type. To begin with, the two types are much alike—a fact which probably explains why Claus (1872) called his fig. 12 an *Erichthus* ; at this stage the submedian teeth are well separated and the intermediate teeth are well anterior to them. During later stages the intermediate teeth are carried posteriorly so that they are nearly level with the submedians, the latter coming very close together and taking up the positions which they will occupy in the adult. In *Erichthus* larvæ, on the other hand, although the submedian teeth come close together in the adult stage, they remain widely separated in the larval stages, and, as the figures of Giesbrecht (1910) clearly show, the telson undergoes much transformation in the post-larval stages. I have elsewhere (1932, p. 382) remarked on the early assumption of adult characters in *Alima* larvæ, and have pointed out that the prolongation of larval life, which appears to have taken place in this genus, comes at the end rather than at the beginning of the larval stage ; this of course emphasizes the distributive function of these larvæ.

Brooks (1886), and more recently Lebour (1934), have urged that the only satisfactory method of dealing with the problem of the specific identity of the larvæ is to rear them until the post-larva is obtained ; until this can be done there is little hope of making great progress in the study of these forms. Komai (1932) has described how the larvæ attributed to *Squilla oratoria* can be dried, stained pink, powdered, bottled and sold under the name of " Ebi-no-sei " (essence of shrimp) ; it would appear a point for debate whether this is not a more desirable fate for *Squilla* larvæ than to occupy space in museum collections under the somewhat hopeless designation of *Alima* sp.

It is convenient to deal with the *Alima* larvæ in three groups : firstly, those near *Squilla nepa*, secondly, those near *Alima robusta*, and thirdly, those near *Alima multispinus*.

Squilla spp. (" *nepa* " group).

[*Alima* spp.]

Occurrence.—Station 7 (Red Sea), Station 61 (Northern area of Arabian Sea), Stations 71, 76 (Gulf of Oman), Station 131 (Southern area of Arabian Sea), Station 145 (Maldive Area), Station 172 (Central area of Arabian Sea), Station 186 (Gulf of Aden).

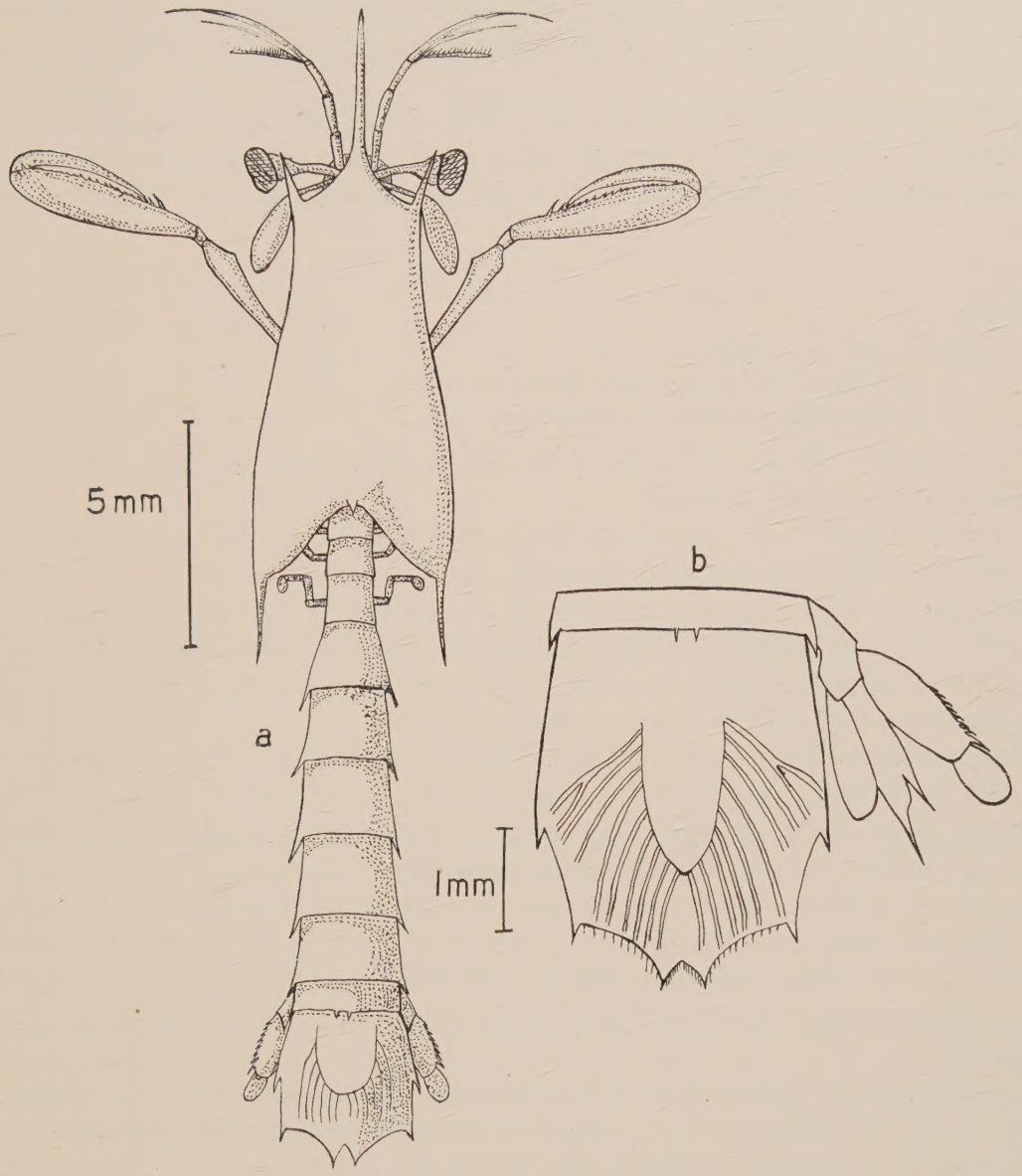
Remarks.—These specimens all resemble the larvæ described by Komai and Tung (1929) from Japan as the larvæ of *Squilla oratoria*. There is no doubt that the John Murray Expedition specimens belong to closely related species, but they are slightly larger than the larvæ of *S. oratoria*, not being fully grown at 25 mm. In the present state of our knowledge it is impossible to say whether more than one species is represented in the collection, but it is highly probable that there are several present.

By far the greatest numbers were obtained at Station 186, where close on four thousand specimens all apparently belonging to the same species were obtained ; a large number of specimens were also taken at Station 7, these being more fully developed. It is considered unlikely that the larvæ from these two stations belong to the same species, although it is possible. But, from their general similarity to the larvæ of *Squilla oratoria*, it is fairly certain that these larvæ belong to adults of the " *nepa* " group. One from Station 7, about 25 mm. in length, is represented in Text-fig. 1 ; the carapace, which, at this stage, leaves the last three thoracic segments uncovered dorsally, is very flat, although the " zœa " spine is raised on a small triangular prominence at the posterior edge of the carapace ; it is also very thin and delicate in appearance. The telson is rather longer than broad.

It is attractive to suggest that the large numbers found at Station 186 belong to *Squilla investigatoris*, which is very abundant in this region (see Chopra, 1939), but, apart from the distribution, these is little other evidence to support this view. With regard to those from Station 7, which is in the Red Sea, it is of interest to note that Dollfus (1938) has given a revised list of adult Stomatopoda found in this area. He records five species of *Squilla*, including *S. massavensis*, *S. wood-masoni* and *S. multicarinata* ; the shape of the uropod (see Text-fig. 1, *b*) shows that the larvæ might well belong to any of these species. The peculiar markings on, or in, the telson are suggestive of *S. multicarinata*, but further evidence will have to be forthcoming before a definite allocation of the larva to an adult can be made.

Three rather damaged specimens, slightly bigger than those from Station 7, and belonging to the same or a nearly related species, were caught in the Gulf of Oman at

Station 71. One of these specimens showed five spines on the dactylus of the raptorial claw (including the terminal one). This is the typical number of the *quinquedentata* group, so that there is a chance that these larvæ do not belong to the "*nepa*" group;



TEXT-FIG. 1.—*Alima* sp. (*a*) Dorsal view of a specimen 25 mm. long. (*b*) Telson of a similar specimen showing the markings referred to in the text.

but it is most likely that another spine might be added at a subsequent moult. It is, however, worth noting that Dollfus (1938) has recorded *S. gonypetes* from the Red Sea.

At the remaining stations fewer specimens were taken and at some stations only one specimen. It will be noted that all the stations at which these larvæ occurred were comparatively near land—a point which will be further commented upon in the section on distribution.

Squilla sp.

[*Alima* sp. near *robusta*, Jurich, 1904.]

Occurrence.—This species was not met with nearly so frequently as the preceding type ; several specimens were taken at Station 61 (Northern area of the Arabian Sea), 2 specimens at Station 86 (same area), and 3 at Station 172 (Central area of the Arabian Sea).

Distribution.—Jurich's specimens were from the Indian North Equatorial Current.

Remarks.—This species is very like those of the preceding group except for a larger and longer carapace ; probably the adult is not far removed from the " *nepa* " group.

Squilla sp.

[*Alima multispinus* (Claus).]
[*Erichthus multispinus*, Claus, 1872.]
[*Alimerichthus multispinus*, Borradaile, 1907.]

Occurrence.—Station 7 (Red Sea), Station 61 (Northern Area of the Arabian Sea), Stations 71 and 76 (Gulf of Oman).

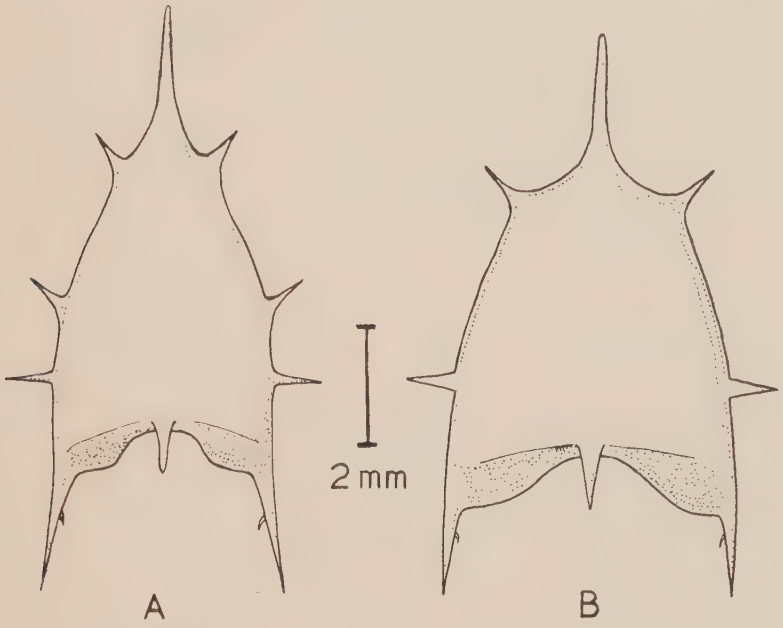
Distribution.—Claus's specimen came from the Indian Ocean, and Borradaile's specimens from Saloman Atoll and Desroches Atoll.

Remarks.—It is uncertain whether the specimens in the collection all belong to this species, or whether some of them belong to another, nearly related, one ; but, as I am unable to suggest an adult to which these larvæ might belong, I prefer to deal with them together rather than to create a new larval name.

The specimens fall into two groups. Firstly those which closely resemble Claus's figure (12) of *Erichthus multispinus*, but bear, in addition, the small tooth on the spines of the hinder angles of the carapace mentioned by Borradaile. Borradaile says that in his specimens the foremost of the spines on the lower edge of the carapace is very much larger than is shown in Claus's figure ; in the specimens in this collection this spine is directed more ventrally than its posterior companion, to which it is almost equal in size. The fact that in Claus's figure this spine appears shorter may be due to foreshortening. These typical specimens were found as follows : seven at Station 7, one at Station 61 and one at Station 76.

Secondly, in addition to the typical specimens, others were found at Station 7 (4), Station 71 (2) and Station 76 (1) which are almost identical with *Alima multispinus*, but have only one laterally directed spine on each side of the carapace. Text-fig. 2 shows the two types of carapace in dorsal view for comparison ; this second type appears to be that figured by Claus in his fig. 30. Claus's specimen was 18 mm. in length, and his figure shows eight teeth, including the terminal one, on the dactylus of the raptorial claw and eight spines on the exopodite of the uropod. A specimen from Station 7, 18 mm. in length, shows seven incipient teeth on the raptorial dactylus and nine spines on the uropod. A specimen of the more typical *A. multispinus* 20 mm. long from Station 61 shows four dactylar teeth already free and three more still covered by the larval skin, and the exopodites of the uropods show eight spines on one side of the body and seven on the other. If these two types of larvæ really do belong to two species of adult *Squilla*, the adults must be very closely related.

When any attempt to refer these larvæ to their adults is made the comparatively large number of teeth on the raptorial dactylus should be borne in mind. It is unlikely that larvæ of this general shape belong anywhere near *S. nepa* or *S. oratoria*, which would rule out the possibility of their belonging to *S. investigatoris ; S. armata* is unlikely for geographical reasons ; therefore, of the species of *Squilla* listed by Kemp (1913) as having this large number of teeth on the raptorial dactylus, only *S. raphidea* and *S. annandalei* remain. However, this can hardly be considered as more than a guess.



Text-fig. 2.—*Alima multispinus*. Dorsal view of carapace of (*a*) typical form ; (*b*) the same or a closely related species.

Pseudosquilla, Dana.

According to Kemp, this genus is to be regarded as that most closely allied to *Squilla*, but its larvæ are quite different in appearance from the *Alima* type, and, in their earliest stages at least, are difficult to separate from those of *Gonodactylus* and *Odontodactylus*. It is largely this difficulty that has led to the modifications in the " key " given above. However, I believe that a useful character by which these larvæ can be distinguished from all other types of Stomatopod larvæ is by the very early development of the uropods, which in quite early stages—not the first, however—come to be equal in length to the telson, the spinous process from the base of the uropod being especially conspicuous.

Another peculiarity of some of the larvæ of this genus should be mentioned here ; it concerns the pectination of the upper margin of the propodus of the raptorial claw. This fine pectination of the propodus is a character typical of all adults of this genus, and in the majority of larvæ it can be seen developing during growth. It is well marked in the following figures of *Pseuderichthus* larvæ : *P. elongatus*, Hansen (Claus, fig. 25), *P. affinis*, Borradaile (Claus, fig. 23), and the larvæ of *Pseudosquilla constricta*, *P. caudata* and *P. ferussaci* (?), figured by Giesbrecht (1910) on his plate 11, figs. 4, 57 and 77 respectively.

However, when we turn to *Pseuderichthus communis*, Hansen (larva of *Pseudosquilla ciliata*), and *P. distinguendus*, Hansen (larva of *Pseudosquilla oculata*), we find that in Claus's figures (Claus, figs. 26, 27A, 27B, 27C) this pectination is absent, as it is in the specimens in the British Museum collection. Through the kindness of Dr. Smith, of the University Museum of Zoology, Cambridge, I have also examined Borradaile's specimens, and these too, show that the pectination is absent. However, in some cases it is possible to distinguish a few scattered spinules on the upper margin of the propodus of the raptorial claw. According to Bigelow (1931) the " monodactyla " stage of *Pseudosquilla oculata* has a series of fine hairs in this position in place of the pectinations of the adult. Jurich (1904, pl. 38, fig. 5) figures a specimen which he attributes to *Pseuderichthus distinguendus*, and which shows pectination on the propodus of the raptorial claw ; however, in view of all the other figures and my examination of certain specimens, it must be concluded that Jurich was mistaken, either in placing the larva in this species, or in drawing the pectination on this joint ; it may be noted that Hansen (1926) has likewise questioned the accuracy of Jurich's drawing of *Lysioerichthus duvaucellii*.

Pseudosquilla ciliata (Fabricius).

[*Pseuderichthus communis*, Hansen, 1895.]

Occurrence.—Station 7 (Red Sea), 10 specimens.

Distribution.—The adult of this species is known to have a very wide distribution throughout the " tropical and warmer temperate seas (Hansen, 1926) ". A list of places at which the adult has been found has been given by Kemp (1913), who includes a record for the Red Sea made by Nobili ; he also gives a list of occurrences of the larva which is as follows : " Indian Equatorial current (Jurich) ; from Ceylon (Tattersall) ; and from the Chagos Archipelago, Alphonse Is., Amirante group, Providence Is., and between Mauritius and Cargados (Borradaile). In the Atlantic it has been recorded from the Sargasso Sea and the N. Equatorial current (Hansen)." The Red Sea would appear therefore to be a new locality for the larva, and we should also add to the Atlantic distribution the specimens found by the " Terra Nova " off the Brazilian Coast (Calman, 1917). Chopra (1939) records a " monodactyla " stage from Station M.B. II (South Arabian Coast).

Remarks.—The specimens are all about 21 mm. in length and are quite typical.

Pseudosquilla sp. (? *oculata* (Brullé)).

[? *Pseuderichthus distinguendus*, Hansen, 1895.]

Occurrence.—Station 76 (Gulf of Oman), 1 specimen, Station 172 (Central area of Arabian Sea), 12 specimens.

Distribution.—This well-known larva has been recorded both from the Atlantic and Indo-Pacific regions.

Remarks.—The specimens, which I refer with a considerable degree of hesitation to this species, are all small. The largest is one from Station 172 and measures about 15 mm. in length. The remaining specimens are all smaller than this and do not exceed 10 mm. long. They differ from the older larvæ of this species, which have been described by

other authors, in having all the spines of the carapace longer, and they possess a fairly well-developed " zœa " spine. In general appearance they somewhat resemble *Pseuderichthus affinis* as it is shown in Claus's fig. 23, but can be immediately distinguished from it by the absence of any secondary spines near the base of the postero-lateral spines and by the presence of spinules on the underside of the rostrum. These larvæ are referred to *P. distinguendus* rather than to *P. communis* on account of the prominence of the "zœa" spine ; from Claus's figures it would seem that the former species tends to retain this spine longer than the latter. A point which may be worthy of note is that the spinules on the upper margin of the propodus of the raptorial claw are quite prominent even in the early stages.

Lysiosquilla, Dana.

Lysiosquilla maculata (Fabricius).

[*Lysioerichthus duvaucellii* (Guerin).]

[*Lysierichthus Duvaucellii*, Hansen, 1926, with synonymy.]

[*Lysioerichthus duvaucellii*, Tattersall, 1906.]

[*Lysierichthus duvaucelli*, Borradaile, 1907.]

Occurrence.—Stations 86 (Northern area of Arabian Sea), 96 (Central area of Arabian Sea), 145 (Maldive area) and 172 (Central area of Arabian Sea).

Distribution.—This species is known from almost the entire Indo-Pacific region.

Remarks.—Hansen (1926), in his " Siboga " report, has treated this larval species in a somewhat peculiar fashion. He has apparently overlooked the records of both Borradaile and Tattersall, and, in the latter case, this is an unfortunate omission, as Tattersall raised important questions which should be taken into account by later workers. Also Hansen gives some reasons for believing that this larva belongs to *Lysiosquilla maculata*, and omits the fact that this relationship was first suggested, and, indeed, practically proved, by Brooks (1886), who found that one of the later larvæ in the " Challenger " collection displayed the pigment-bands so characteristic of the adult.

Tattersall (1906) drew attention to several discrepances in the descriptions by various authors of the larvæ referred to this species, perhaps the most important being the presence or absence of the " zœa " spine. He suggested that the larvæ referred to this species might really belong to more than one species. The larvæ in the present collection do not, unfortunately, throw any great light on this matter ; of the three larger specimens the one from Station 86 had no " zœa " spine, while the other two, from Station 96, have this spine present, otherwise the three specimens, all about 22 mm. long, appear equally developed.

I also refer to this species some very early larvæ found at Stations 145 (2 specimens) and 172 (3 specimens). They appear identical with the larvæ called by Claus (1872) *Erichthoidina armata* and shown in his fig. 3. Claus's specimens have, however, been referred by Hansen (1895) to the Atlantic species *Lysierichthus edwardsii* (Eyd. and Soul.). My chief reason for referring these small larvæ to *L. duvaucellii* is that they possess median lateral spines on each side of the carapace.

Lysiosquilla sp. (? *multifasciata* Wood Mason).

[*Lysioerichthus rostratus* (Borradaile).]
[*Erichthus* (? *Odonterichthus*) *rostratus*, Borradaile, 1907.]
[*Coronideríchthus rostratus*, Foxon, 1932.]
[? *Erichthus* sp., Claus, 1872.]
[? *Lysioerichthus* β Tattersall, 1906.]
[? *Lysioerichthus* sp., Komai and Tung, 1929.]

Occurrence.—Station 61 (Northern area of Arabian Sea), 1 specimen, Station 172 (Central area of Arabian Sea), 10 specimens.

Distribution.—If all the larvæ mentioned in the synonymy above really do belong to the same species it will be seen that it has a very wide distribution. Borradaile's specimens were from Alphonse Is., and the specimens which I described as belonging to the same species as his were from the Great Barrier Reef. If, as I hope to show, the other larvæ mentioned also belong to the same species the distribution extends to Japan, and Tattersall's specimens were from the Gulf of Manaar.

Text-fig. 3.—*Lysioerichthus rostratus*. Side view of a carapace of a specimen 7 mm. long.

Remarks.—The specimen from Station 61 and one of those from Station 172, although not so well developed as Borradaile's specimens, are, nevertheless, quite typical; of the remaining nine specimens from Station 172 some are definitely *Lysioerichthus rostratus*, but, in the very youngest specimens, there is great possibility of confusion with the first stages of *Coronideríchthus bituberculatus*; in early stages these two species are indistinguishable. The later development of this species can be followed in the specimens in the present collection. Text-fig. 3 shows the carapace of the 7–mm. stage; here the postero-lateral spines reach as far as the end of the telson so that the carapace length is the total length of the larva. The raptorial claw is developed but the three following appendages are still biramous. The carapace shows the infolding of the posterior half of the sides, which is not nearly so marked in this species as it is in *C. bituberculatus*; the rostrum shows its characteristic curving and has five conspicuous spinules on its under surface; the spine at the base of the postero-lateral spines continues prominent and does not disappear as in *C. bituberculatus*, and the "zœa" spine remains much shorter than in that species.

It seems very likely that *Erichthus brevispinosa*, Claus (1872, figs. 4 and 5) are young stages of this species; Tattersall (1906) has pointed out that these figures are not of *Gonodactylus* larvæ as Brooks (1886) thought.

There are several problems concerning this species which must be discussed. Firstly, are all the synonyms mentioned above valid ?

In 1932 I stated that the specimens of this species from the Great Barrier Reef were "identical with both the figures given by Claus and with the actual specimens collected

by the 'Sea-Lark' Expedition". It has now been noticed that Claus's fig. 19*g* of the raptorial claw shows no pectination on the upper margin of the propodus—a character which I remarked at the time was present in this species. Through the kindness of Dr. I. Gordon I have been able to re-examine two of Borradaile's co-types. These show distinct pectination on this joint; in neither specimen, however, is the rostrum complete, so that the presence or absence of the upward curve could not be determined. I believe that I am now dealing with the same species as Borradaile, but that some doubt must exist as to whether he was correct in assuming his specimens to belong to the same species as those figured by Claus, for the latter shows no pectinations on the propodus of the raptorial claw and the rostrum is straight and not curved. From the figures given by Tattersall (1906) and by Komai and Tung (1929) it seems most likely that these authors were also dealing with this species, but Komai and Tung do not discuss the possibility of their larvæ belonging to the same species as those of Tattersall, although his paper occurs in their list of references.

Tattersall also describes the development of his larvæ and it is very similar to what I have recorded here; this is an additional argument for regarding these two forms as belonging to the same species.

Secondly the question arises as to whether this larval species belongs to *Lysiosquilla* or to *Coronida*.

In 1932 I suggested that this species belonged to *Coroniderichthus*. As pointed out above, the larvæ in their youngest stages are very similar to those of *C. bituberculatus*, but, for other reasons, it seems more satisfactory to regard these larvæ as *Lysioerichthus*. Firstly, if this was a *Coronida* larva we should expect to find two common species of *Coronida* in the Indo-Pacific region; this is not the case. However, this is not a conclusive argument, as Calman (1917) has remarked that the abundance of the larvæ of *Coronida bradyi* in the warmer parts of the Atlantic is in striking contrast to the extreme rarity of the adult. Secondly, the introduction of this species into the genus *Coronida* would introduce a new carapace shape for this genus, for both *Coroniderichthus armatus* and *C. bituberculatus*, when looked at from the dorsal aspect, have a carapace that is triangular in outline and also is highly vaulted. If we were to accept the *Coronida* hypothesis, we would have to assume that the peculiar variations of carapace shape found in the larvæ of *Lysiosquilla* are to some degree paralleled in *Coronida*. The shape of the larva under discussion is, however, one that is already known from the genus *Lysiosquilla*, and Komai and Tung (1929) point out that their larvæ are very like those ascribed to *L. occulta* by Giesbrecht (1910). Thirdly, the degree of inflation of the propodus of the raptorial claw, by which it is possible, according to Hansen, to separate *Coronida* larvæ from those of *Lysiosquilla*, is not an easy point to determine, and although in some specimens this joint appears rather inflated, in others it is less so. Altogether in view of these arguments it seems preferable to refer this larva to *Lysiosquilla* rather than to *Coronida*.

As to the view of Komai and Tung that this larva may be that of *Lysiosquilla multifasciata*, it is impossible to advance any evidence which might lead to a positive conclusion. The following details of distribution of the adult may be pointed out. The distribution seems wide and extends to Japanese waters; Kemp (1913) doubted Nobili's determination of specimens from Obock in the Red Sea, but Chopra (1939) points out that this species undoubtedly does live in the Red Sea, and also records nine adults from Station 72 (Gulf of Oman).

Coronida, Brooks.

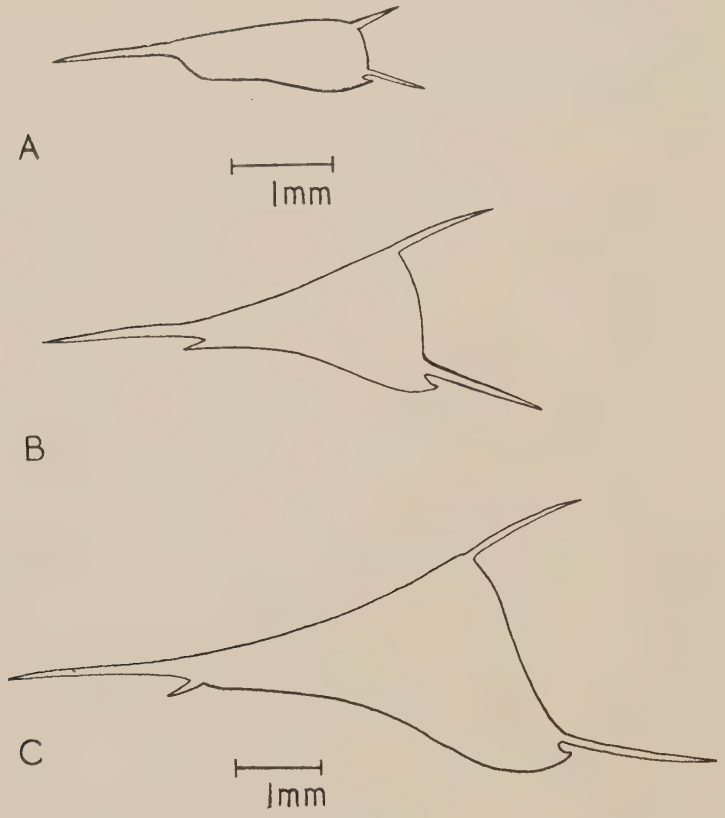
Coronida sp. (? *trachurus*, v. Martens).

[*Coroniderichthus bituberculatus*, Hansen.]

[*Coroniderichthus bituberculatus*, Hansen, 1926 with synonymy.]

Occurrence.—Station 172 (Central area of Arabian Sea), 9 specimens; Station 186 (Gulf of Aden), 2 specimens.

Distribution.—This species is known from the Indian North Equatorial Current (Jurich, 1904), and Hansen's (1926) specimens came from the Phillipines.



Text-fig. 4.—*Coroniderichthus bituberculatus*. Side view of carapace at various stages of development: (*a*) " Erichthoidina " 4-mm. stage; (*b*) 6-mm. stage; (*c*) 12-mm. stage.

Remarks.—The specimens in the collection cover nearly the whole of the developmental stages. The largest specimen, which measures 12 mm., from Station 186, is nearly fully grown; the only conspicuous difference between this and Claus's (1872) fig. 15 is that in this specimen there are no conspicuous spinules on the underside of the rostrum. It is extremely difficult to differentiate between the young stages of this species and those of *Lysioerichthus rostratus*; a length of 6 mm. is the earliest stage at which it is possible to be quite certain that a larva belongs to this species; these have the raptorial claw developed, but the three following pairs of appendages are still biramous and the antero-lateral spines of the carapace have appeared (Text-fig. 4*b*). By the time that a length of 8 mm. has been attained the transformation of the remaining thoracic appendages has commenced, and this is complete in specimens of 12 mm. The hook-like spines at the bases of the

postero-lateral spines of the carapace have a peculiar history. Text-fig. 4*a* shows an Erichthoidina of 4 mm. which, from the proportions of the " zœa " and postero-lateral spines, and from the fact that the edges of the posterior half of the carapace show signs of ventral folding, is probably to be referred to this species ; here there are as yet no antero-lateral spines on the carapace, but the hook-like spines at the bases of the postero-lateral spines are clearly seen. These hook-like spines become more prominent in subsequent stages, but, by the time that the 12-mm. stage (Text-fig. 4, *c*) is reached they have begun to decline, and Claus's figure of a fully developed larva shows that they have disappeared ; this sequence of events is somewhat different from what happens to these same spines in *Lysioerichthus rostratus*.

Komai and Tung (1929, p. 216, fig. 1) refer to *Lysioerichthus* sp., a larva which is not unlike the present species ; they do not, however, suggest that it belongs to this or to any other species. Indeed this part of their work is somewhat difficult to follow, as despite the fact that Hansen (1895) long ago pointed out that differences exist between the *Lysioerichthus triangularis* of Milne-Edwards and that of Brooks, they have regarded the two species as synonymous.

DISTRIBUTION.

(*a*) Horizontal :

It has been pointed out above that the large collections of *Alima* larvæ were made at stations relatively near the large land masses, and this seems to go a long way to providing proof that the elongation of larval life found in this genus is of importance in distribution. *Alima* larvæ in small numbers were, however, found at all the stations at which Stomatopod larvæ were taken except Station 96, where a single *Lysioerichthus duvaucellii* was obtained. This species was also found at several other stations, but not in the Red Sea, Gulf of Aden or Gulf of Oman. *Pseuderichthus* larvæ were, on the other hand, found both in the Red Sea and Gulf of Oman and also at Station 172 ; at the latter station *Lysioerichthus duvaucellii*, *L. rostratus*, *Coronideriehthus bituberculatus* and two types of *Alima* were also found.

To summarize, one receives the impression that *Alima* larvæ occur almost everywhere, but in greatest numbers near the coast ; that *Pseuderichthus* larvæ are also likely to be found near land ; and that *Lysiosquilla* larvæ are those most likely to be found furthest from land. As for *Coronideriehthus bituberculatus*, its occurrence at only two stations, one in the Gulf of Aden and the other Station 172, does not permit of any generalizations.

(*b*) Vertical :

At Station 61, during the day, although various larvæ were caught in different nets fishing at depths down to 2000 metres (2265 m. of wire out), none was taken at the surface. But, during the night, the surface net caught *Alima* larvæ of the " *nepa* " and " *robusta* " types and also a specimen of *Lysioerichthus rostratus*, but larvæ were still being taken in the 2000 m. net. It would appear that, although there was no definite upward migration of the larvæ at night, there is a tendency to follow the general rule found amongst plank-tonic crustacea to move upwards at night. It should be pointed out, however, that Borradaile (1907) records several Stomatopod larvæ as having been taken at the surface during the hours of daylight.

The occurrence of the large specimens of *Lysioerichthus duvaucellii* in the deeper nets at Stations 86, 96, 145D and 172, together with the fact that the only *Alima* larvæ in which spines were developed on the raptorial dactylus were caught in the Otter Trawl at Station 71, suggest that, in these genera at least, the final larval moults take place nearer the bottom than the earlier ones.

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